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Preventive maintenance system development project management: A case study in a medium scale industrial factory

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Abstract

This research provides a case study of the management of preventive maintenance system based-on PMBOK® GUIDE 2004. It presents a proposed model of information systems development in a medium scale industrial factory, that doesn't require information technology staff. The proposed model includes five phases of IT project management. These are 1) initiating process group 2) planning process group 3) executing process group 4) monitoring and controlling process group and 5) closing process group. Results from the testing of the model have shown that seven knowledge areas are required for successful implementation in a medium scale industrial factory. The results from the research showed that the development of a preventive maintenance system using PMBOK® GUIDE 2004 and extreme programming can be completed within budget and meets the users' needs.

Keywords: project management, preventive maintenance system, medium scale industrial factory

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1. Introduction

Small and medium-sized enterprises are currently seen as key mechanisms in strengthening the economic progress of Thailand. They create income and employment as well as operating as a tool for poverty alleviation. In 2010 the total number of enterprises in Thailand was 2,924,912. Most of these were small and medium-sized enterprises. Statistics show that small and medium-sized enterprises employ 77.86 percent of all employed people in the country. In addition to this, the Gross Domestic Products (GDP) of small and medium-sized enterprises in Thailand contributed 42.35 percent of the country's GDP [1]. The analysis of strengths, weaknesses, opportunities, and threats found that small and medium-sized enterprises had limitations including their abilities in technology development and innovation. Several problems have been identified that are holding back the growth of these establishments. These problems were a loss to enterprises with better information technology systems [2]. This study studied a medium scale industrial factory which produces industrial grade limestone for use in the construction industry. The researchers found that if industrial factories did not operate preventative maintenance systems it directly affects the production process, delivery process, and sales. It also contributes to higher operating costs. The industry should, therefore, use preventive maintenance in order to prevent these problems. The issues holding back the introduction of preventative maintenance systems in Thailand were found to be as follows; 1) The industry lacks information management and efficient maintenance systems. This causes unscheduled stops to the production line. 2) The manual maintenance systems that were in use during the research were not effective. 3) Preventive maintenance systems were not being used in the factory. 4) The factory did not have IT staff. 5) The factory did not have experience in applying the information systems development theory. The researchers aimed to apply the PMBOK GUIDE 2004 theory of preventive maintenance system development in a medium scale industrial factory. The project was completed within budget and was shown to meet the users' needs.

2. Materials and methods

2.1 Project Management Institute: PMI

The Project Management Institute (PMI) is a non-profit organization for project management. It offers the Project Management Professional (PMP)® certification that recognizes knowledge and competency in project management. It has obtained the ANSI/ISO/IEC 17024 accreditation from the International Organization for Standardization (ISO) [3]. It has produced the Project Management Body of Knowledge Guide (PM

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BOK Guide). The PMBOK 1st Edition was issued in 1987 [4].

2.2 Project Management

The PMBOK® GUIDE 2004 has been widely applied and has been shown to be effective when it is used for project management procedures. All projects consist of different factors as determined by their scope. These factors are the objective (What work will be done as part of the project?), time allocation (How long should it take to complete the project?), and cost (What should it cost to complete the project?) goals [5]. These three factors are called the triple constraints are represented as a triangle. They directly affect the success of the project [6]. Project managers have to manage triple constraints in order to measure and control the project. There are nine areas of knowledge in the field of project management. These are composed of four core knowledge areas which are 1) project scope 2) time 3) cost and 4) quality management. They also consist of four facilitating knowledge areas which are 1) human resources 2) communications 3) risk and 4) procurement management. The final of the nine areas of knowledge is projected integration management [5]. Figure 1 shows the relationship between each knowledge area.

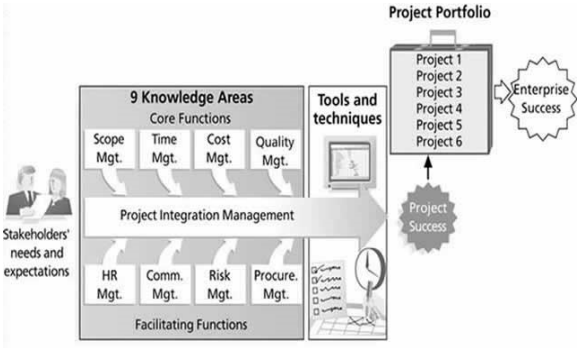


Figure 1 Project management framework [5].

2.3 Preventive Maintenance

Preventive maintenance is planned maintenance of machinery and equipment. It is used to prevent damage or as a planning, precaution to prevent the need for stopping the production line during a production run [7]. Preventive maintenance systems mainly consist of basic functions, such as 1) machinery details 2) if the machine is complaint or in need of repair 3) maintenance plans 4) emergency repair work required 5) spare parts inventory and details of any spare parts shipments 6) reports 7) cost of repairs and 8) buying the latest information.

2.4 Extreme Programming

Extreme Programming (XP) is an approach to software development. It is an iterative and incremental development guideline which is well-suited to support small software development teams. XP is also flexible and works closely with the customer. the software that is developed will, therefore, meet users' needs. The XP process is divided into four stages including planning, design, coding, and testing [8].

2.5 Related Research

Vijja Phetchsena [9] studies the design of a decision support system for the management system of preventive maintenance in a hotel. The refrigeration systems are selected for creating preventive maintenance records which include the monthly maintenance cost of each machine in the system. The decision support system was designed using a computer program. After using the decision support system it was found that the time spent searching for information was reduced by an average of 77.03 percent. In terms of finances, this led to a decrease in costs of THB 63,875 per person per year when compared with the previous system. It is concluded that the hotel maintenance administration program is appropriate for hotels who wish to become more competitive.

Pongpipat Khumlamay [10] developed inventory management systems for the beverage industry. Their project found ways to reduce the problems that occur in warehouse management in the industry. The results of the project showed that the industry could reduce their production time by 13.04 percent.

Visit Promrat [11] studied information systems for leased line service installation using agile methods of project management. They presented a case study in Satun Customer Service Sector, TOT Public Company Limited, Thailand. The concept of the research was to improve the working system of installation for a leased line to the Satun Customer Service Sector, TOT Public Company Limited. The problems that were identified were that the process was complex, not up to date and inefficient. It also did not meet the demands of the business. The purpose of the research was to develop the system by adapting the web application used during the installation for a leased line. The research purposes were to manage the project of developing information systems for the installation of a leased line using an Agile Method from the PMBOK Guide 2004. The guide was used to support the coordination between related companies during the systematic installation of a leased line. This process was consistent with the vision and mission of the organization. The researcher concluded that it would lead to more efficient processes and increased customer satisfaction. It was found that using an Agile Method to run the research enabled the project to be managed efficiently and effectively. It was found to be able to manage time, cost, quality, human resources, communications, risks, and project integration in order to meet with all of the research aims.

Mongkon Youngtanurat and Rangsipan Marukatat [12] developed a Web-Based service system for exchanging latex trading data and predicting latex production volume. The traders' programs sent their data and received aggregate results in exchange. These included the latest average prices and total stocks in the area. This data exchange was carried out via a web service. They could also exchange alerts between themselves. The system that was developed employed a decision tree classifier using data from the Thai Meteorological Department to predict daily latex volume and sent the prediction to client programs. The ability to monitor latex trading and predict daily latex production volumes was seen as a great benefit to latex producers. The system was evaluated by experts in web application development. The results found that users were satisfied with both the usability of the website and its' functionality.

2.6 Research Methodology

The researchers applied the PMBOK® GUIDE 2004 into a medium scale industrial factory that did not have IT staff. The seven knowledge areas of project management were used. This project outsourced the coding, human resource management and risk management of this project. Figure 2 shows the four core knowledge areas and the three facilitating knowledge areas that were important in this project.

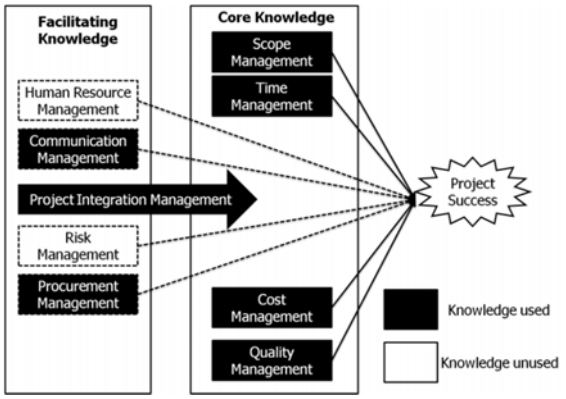


Figure 2 Model of project management knowledge areas for medium scale industrial factory, that doesn't require IT staff.

The project management process group was divided into five groups and their activities were as follows:

2.6.1 Initiating process group

• Set up project team: meeting stakeholders at factory meeting room for start project and assign roles and functions of team members. Using organize technique for team setting. The project teams consisted of the factory team, the project management team, and the information technology outsourcing team.

• Project charter development: engaging stakeholders to discuss the issues and getting agreement to initiate the project. Detail of project charter consisted of the project title, the project start date, the project finish date, budget information, the project manager, the project objectives, success criteria, the approach, roles and responsibilities, names and signatures, roles, positions, contact information, and any comments.

2.6.2 Planning process group

• Developing project scope statement: meeting stakeholders for setting project scope and commitment of team members. Developing a methodology and project scope statement. Carrying out a survey of preventive maintenance software in order to compare the core functions of the bottom-up method. The details of the scope statement produced consisted of the project title, the date, who it was prepared by, the project justification, the product characteristics and requirements, the product user acceptance criteria and finally a summary of the project deliverables, project management related deliverables and product-related deliverables.

• Developing a project schedule: Developing a work breakdown structure. The detail of the work breakdown structure consists of the project name, the main category of the task, the subcategory of the task and the sub-subcategory of the task. The developing of a project Gantt chart. The Gantt chart consists of task names, task durations, predecessors, task milestones and staff responsible.

2.6.3 Executing process group

The extreme programming method was used as follows:

• Planning stage: meeting the project team, users, and information technology outsourcing to identify user requirements and system requirement. A Gantt chart, network diagram and project scope statement were produced at this stage.

• Design stage: Study preventive maintenance system software packages and select the appropriate functions to meet the client requirements. Define the core system functions, outputs, and data flow. The core functions that were required were machine information, inspections, history records, planned maintenance task generation, planned maintenance schedule generation and maintenance due to notifications. A user case diagram was designed. The development of a user-friendly interface, for example, the command menu has useful functions etc.

• Coding: Receiving system design documents, development using Microsoft Visual FoxPro 9.0.

• Testing: Applying black-box and V-Model testing. The user was involved in system testing during each phase of the development phase, i.e. unit testing, integrating testing, system testing, and acceptance testing. All components were tested ensuring each

component met its specification. The developer then deployed software to an active user environment for beta testing.

2.6.4 Monitoring and controlling process group

The project manager used Gantt charts to monitor and control the project scope and time. Milestones were used to monitor project progress. Cost forecasts were used to control project costs. The communications management plan was used to share project status reports to make sure the communications needs of stakeholders were met throughout the project.

2.6.5 Closing group

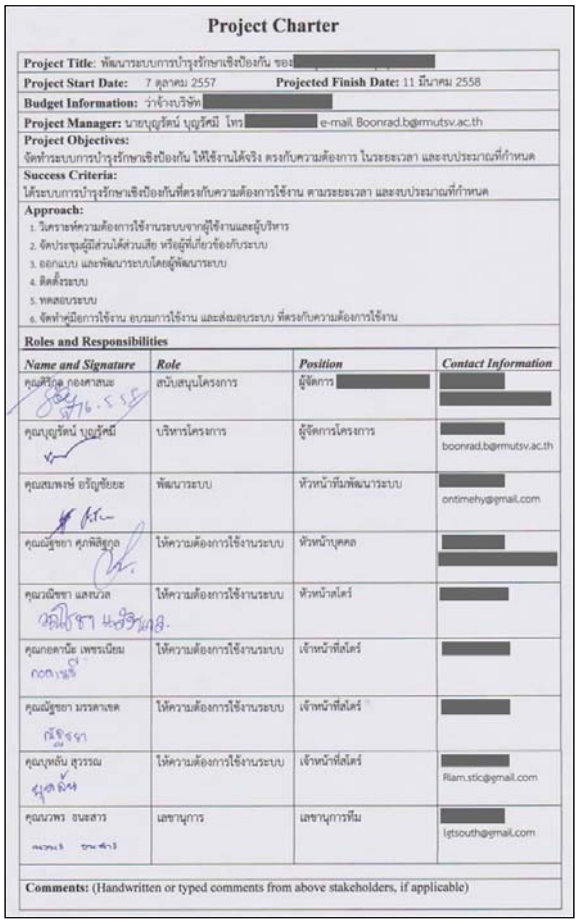
Create and deliver user manuals and final product and reports to the stakeholders.

3. Results and discussion

The results will be discussed under five headings as follows:

3.1 The initiating process group

The result of this process was a project charter. The project charter consisted of project title, start date, finish date, cost, project manager, contact data, the objective of the project, criteria for project evaluation, the process of the project, detail of project stakeholder, role and responsibility, contact data, and stakeholder of project sign off. The five stakeholders in this project were 1) project sponsor 2) project manager 3) system developer 4) end user and 5) project secretary. Figure 3 shows the project charter of the preventive maintenance system that was developed.



Project Charter

Project Title: พัฒนาระบบการบำรุงรักษาเชิงป้องกัน ของ[redacted]

Project Start Date: 7 ตุลาคม 2557 **Projected Finish Date:** 11 มีนาคม 2558

Budget Information: ว่าจ้างบริษัท[redacted]

Project Manager: นายบุญรัตน์ บุญรัศมี โทร[redacted] e-mail Boonrad.b@rmutsv.ac.th

Project Objectives:
จัดทำระบบการบำรุงรักษาเชิงป้องกัน ให้ใช้งานได้จริง ตรงกับความต้องการ ในระยะเวลา และงบประมาณที่กำหนด

Success Criteria:
ได้ระบบการบำรุงรักษาเชิงป้องกันที่ตรงกับความต้องการใช้งาน ตามระยะเวลา และงบประมาณที่กำหนด

Approach:
1. วิเคราะห์ความต้องการใช้งานระบบจากผู้ใช้งานและผู้บริหาร
2. จัดประชุมผู้มีส่วนได้ส่วนเสีย หรือผู้ที่เกี่ยวข้องกับระบบ
3. ออกแบบ และพัฒนาระบบโดยผู้พัฒนาระบบ
4. ติดตั้งระบบ
5. ทดสอบระบบ
6. จัดทำคู่มือการใช้งาน อบรมการใช้งาน และส่งมอบระบบ ที่ตรงกับความต้องการใช้งาน

Roles and Responsibilities

Name and Signature	*Role*	*Position*	*Contact Information*
คุณศิริกุล กองศาสนะ	สนับสนุนโครงการ	ผู้จัดการ[redacted]	[redacted]
คุณบุญรัตน์ บุญรัศมี	บริหารโครงการ	ผู้จัดการโครงการ	[redacted] boonrad.b@rmutsv.ac.th
คุณสมพงษ์ อริญชัยยะ	พัฒนาระบบ	หัวหน้าทีมพัฒนาระบบ	[redacted] ontimehy@gmail.com
คุณณัฐชา ศุภพิสุทธ	ให้ความต้องการใช้งานระบบ	หัวหน้าบุคคล	[redacted]
คุณวณิชชา แสงนวัล	ให้ความต้องการใช้งานระบบ	หัวหน้าคไคร์	[redacted]
คุณกอดานิล เพชรเนียม	ให้ความต้องการใช้งานระบบ	เจ้าหน้าที่คไคร์	[redacted]
คุณณัฐชยา มรรคาเขต	ให้ความต้องการใช้งานระบบ	เจ้าหน้าที่คไคร์	[redacted]
คุณบุหลัน สุวรรณ	ให้ความต้องการใช้งานระบบ	เจ้าหน้าที่คไคร์	[redacted] Rlam.stic@gmail.com
คุณนวพร ธนสาร	เลขานุการ	เลขานุการทีม	[redacted] lgtsouth@gmail.com

Comments: (Handwritten or typed comments from above stakeholders, if applicable)

Figure 3 Project charter

3.2 The planning process group

The results of this process were as follows:

• The project scope statement. This includes project title, date of making project scope document, requirement and product deliverable, criteria for user acceptance, and project deliverable summary. Figure 4 shows the project scope statement that was developed.

Scope Statement

Project Title: พัฒนาระบบการบำรุงรักษาเชิงป้องกัน ของ[redacted]
Date: 7 ตุลาคม 2557 **Prepared by:** ทีมงานโครงการพัฒนาระบบการบำรุงรักษาเชิงป้องกัน

Project Justification:

Product Characteristics and Requirements:
ระบบการบำรุงรักษาเชิงป้องกัน

Product User Acceptance Criteria:
1. สามารถบันทึกข้อมูลเครื่องจักร และรายละเอียดของเครื่องจักร ที่จำเป็นสำหรับการบำรุงรักษาเชิงป้องกันได้
2. สามารถบันทึกข้อมูลแผนการจัดทำการบำรุงรักษาเชิงป้องกันของเครื่องจักรแต่ละชิ้นได้
3. สามารถบันทึกข้อมูลการทำงานเครื่องจักรแต่ละชิ้นได้
4. สามารถดูรายงานผลการบำรุงรักษาเชิงป้องกันตามเครื่องจักรแต่ละชิ้นได้
5. สามารถดูต้นทุนการดูแลรักษาเครื่องจักรแต่ละชิ้นได้
6. สามารถดูรายงานแจ้งเตือนการบำรุงรักษา ตามช่วงเวลา หรือระยะที่กำหนดได้

Summary of Project Deliverables
Project management-related deliverables:
1. Project Charter
2. Project scope statement
3. Work Breakdown Structure (WBS)
4. Project Schedule (Gantt Chart)
5. Final project report
6. Lessons-learned report

Product-related deliverables
1. ระบบการบำรุงรักษาเชิงป้องกัน
2. คู่มือการใช้งานระบบ

Figure 4 Project scope statement

• The work breaks down the structure. This includes the project title and project detail. These were divided into five steps of the project management process group. These were; 1) Initiating process group 2) Planning process group 3) Executing process group 4) Monitoring and Controlling process group, and 5) Closing group. There were three levels of work break down structure. This was to make the data easier for processing, monitoring, and controlling. Figure 5 shows the work break down structure that was developed.

Figure 5 Work break down structure

• The Gantt chart for project schedule included project activities in the form of the work break down structure. There were three levels of the task within this structure. The duration, start date, finish date, sequence activities were also shown. Figure 6 shows the Gantt chart that was produced.

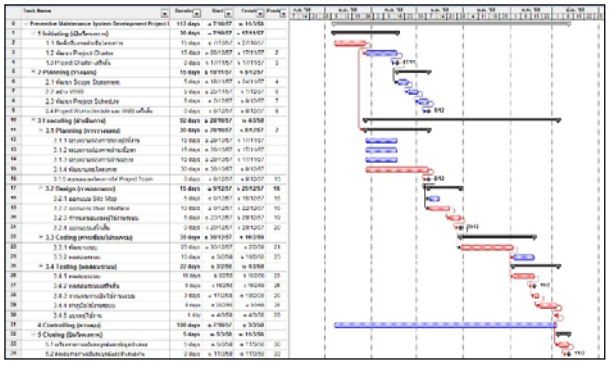


Figure 6 Gantt chart

• The network diagram for the project consisted of a sequence of activities and the critical path of the project. Figure 7 shows the network diagram that was produced.

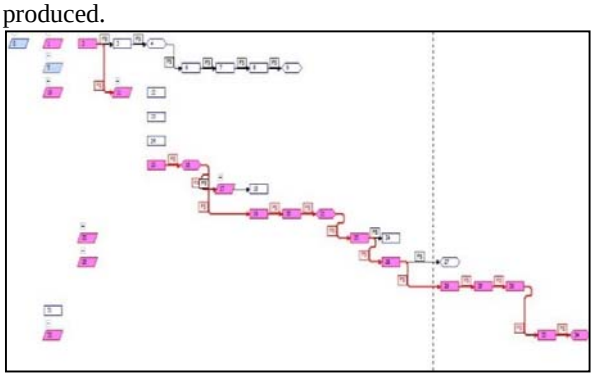


Figure 7 Network diagram

• The project goals or deliverable from important activities were in the form of Milestones. The milestones list includes project title and due-date. 7 milestones were shown in this project as shown in Figure 8.

Milestone List

Project Name: พัฒนาระบบการบำรุงรักษาเชิงป้องกัน[redacted]

Milestone	Estimated Completion Date
1. Project Charter เสร็จสิ้น	17/11/57
2. Project Work Schedule และ WBS เสร็จสิ้น	8/12/57
3. สรุปขอบเขตโครงการให้ Project Team	8/12/57
4. ออกแบบเสร็จสิ้น	29/12/57
5. พัฒนาระบบเสร็จสิ้น	2/2/58
6. ทดสอบระบบเสร็จสิ้น	16/2/58
7. ส่งมอบรายงานฉบับสมบูรณ์และนำเสนองาน	11/3/58

Figure 8 Milestones list

3.3 Executing process group

The results of surveying preventive maintenance software found seven core software functions. These were:

• Machine information: User enters key machine information i.e. machine serial number, machine name, cost of the machine, store location, meter number, and measurements.

• Planned maintenance schedules: The user can select a machine and input maintenance data, frequency, measurements, last preventive maintenance, maintenance schedule, and next maintenance date.

• History record: The user can select a machine and the system shows the machine name and meter number. The user can input data about new meter number and hours or kilometres completed by each machine on a daily basis.

• Reports produced include reports about machine usage time, spare parts inventory, planned maintenance tasks, planned maintenance schedules, and overdue maintenance reports.

• The results from software testing showed that the system met the user's requirements. A suggestion that was made by the user was to improve the graphic user interface. The project management tool used for this process was deliverable acceptance. This document includes the project name, project manager name, project sponsor name, user requirement list, the result of user acceptance testing, signing of stakeholders for system acceptance, and delivery of the system.

3.4 Monitoring and controlling process group

Gantt chart and Milestones are effective tools that support the project manager in monitoring and controlling the project more easily. The project took 66 days more to complete than was planned this was due to delays in the development process.

3.5 Closing group

The results from the closing process showed that:

• Scope and quality: The deliverable preventive management system met user requirements and project sponsor needs. Deliverables that were provided were the final product, the user manual, and user training.

• Cost: The project was completed on budget. The payment date was the final product delivery date.

• Time: The project completed 66 days late. This was because of the developing process which is clearly a part that cannot be skipped. It was found that outsourcing team worked on too many projects at the same time causing the delay.

4. Conclusions

This research provided a case study of the implementation of a preventive maintenance system project and the use of project management tools developed based-on the PMBOK® GUIDE 2004. Researchers presented a new model of the management of an IT project for a medium scale factory that did not have IT staff. Results from the testing of the model found that significant management team knowledge is required. The areas it is required in are core knowledge (i.e. scope management, time management, cost management, quality management) and facilitating knowledge (i.e. communication management, procurement management, and project integration management). The conclusions of this project are as follows:

4.1 Initiating process group

Choosing an outsourcing partner is crucial for the success of an IT project. The factory should conduct a cost-benefit analysis of the internal and external software procurement options to provide an accurate and effective comparison. In order to complete the project successfully a project charter was required. The analogy is an approach where complete user requirements and scope definition are clearly documented. Communication knowledge is also an area used to determine the user's required specifications. This is a powerful technique to elicit all stakeholder requirements. The benefit of documenting these details is the improvement in communication between the users and the developers. Human resources management knowledge was applied to build the project team. The Communications Management Plan was used to manage the communications process. It is where the project manager makes sure that the stakeholders have the information that they need at the time that they need it. This information enables them to do their project work, make decisions, or inform others of the information.

4.2 Planning process group

The factory manager has to apply management knowledge and communication management knowledge in order to create an accurate project scope statement. The seven functions of preventive maintenance systems are as mentioned above. Work breakdown structure has importance in scope and time management. It is required to track the progress in the project schedule. The factory manager also has to also apply their time management knowledge, human resource management knowledge, communication management knowledge, and knowledge of stakeholder requirements in order to develop a project plan and Gantt chart.

4.3 Executing process group

Using an extreme programming development system model was found to be appropriate in this case. Since the factory managers cannot define requirements clearly, user requirement tends to be incomplete or change during the process of the project. In the software testing process, the V-Model ensures that the system is complete and has the desired quality. It also improves the communication between all of the stakeholders. In

this project, all of the end-users were involved in the testing procedure. The developer delivered the final software product, user manual, and training. The project stakeholders were satisfied and have signed off on all deliverables in acceptance form.

4.4 Monitoring and controlling process group

The factory manager has to apply time management knowledge and communication knowledge for monitoring and controlling project through the use of milestones and Gantt charts. In this project, these tools were found to be useful.

4.5 Closing group

Project stakeholders have to participate in closing the project. In a meeting, all stakeholders were in agreement that the project was a success. The user was pleased with the final product it was completed on-scope and on-budget.

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